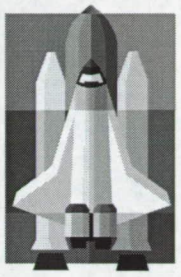
Integrating Human Factors into Space Vehicle Processing for Risk Management



NASA Project Management Challenge 2008

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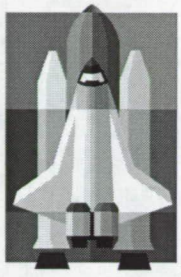

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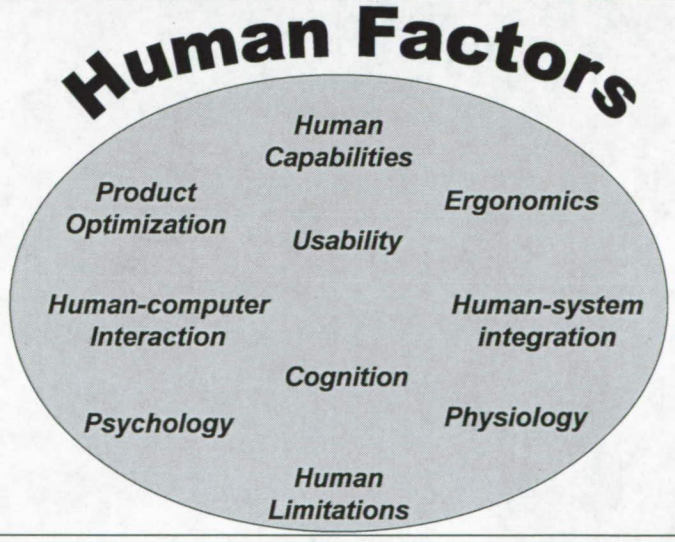
What is Human Factors Engineering?



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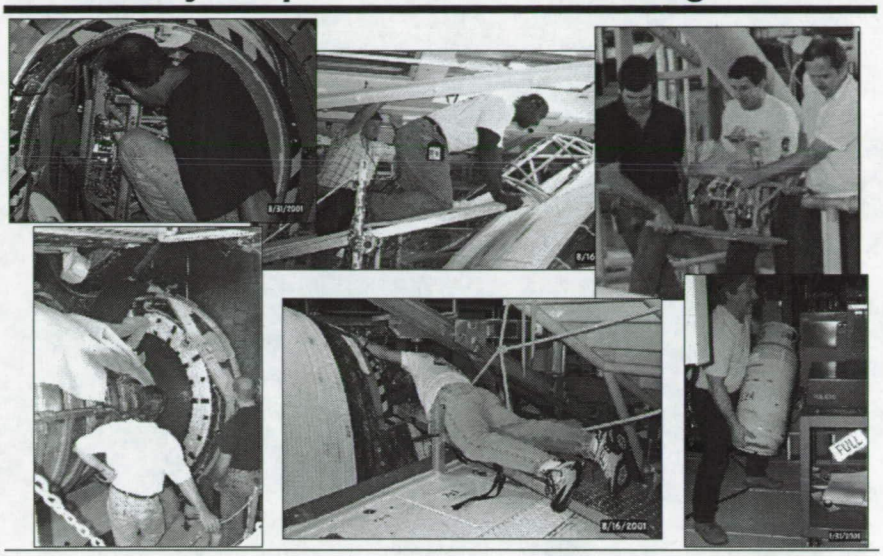
The Reality of Space Vehicle Processing



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Design for Usability…

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Our Goal? Proactive, not Reactive!

- **Consideration of human capabilities and limitations *before* designing products is the *#1* way to manage risk to our most valuable resources: PEOPLE!**

- **Designing products that are intuitive and user-friendly will minimize frustration and human error, resulting in less *$$* spent for redesigns and repairs!**

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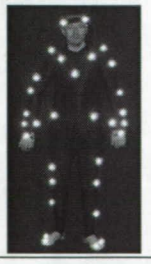
A Step in the Right Direction

- **USA's implementation of the Human Engineering Modeling and Performance (HEMAP) Lab**
  - **Utilizes COTS motion capture system to capture motions of humans and objects, then displays data in a real-time 3D environment**
  - **Utilizes COTS HF modeling software that provides ergonomic analyses of high-risk operations involving heavy lifting, awkward postures, repetitive motions, and difficult reach positions, and process flow operations.**

Cameras capture sensors strategically placed on human body



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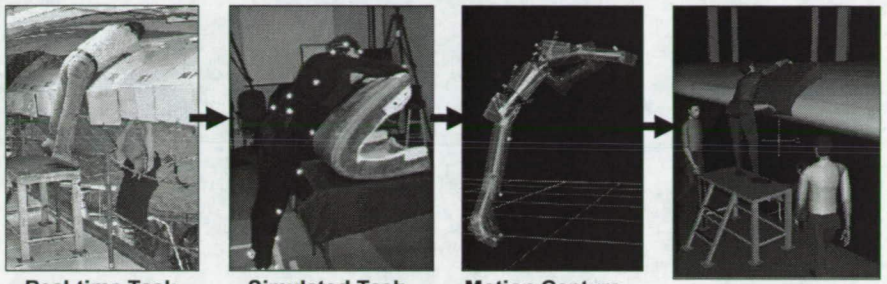
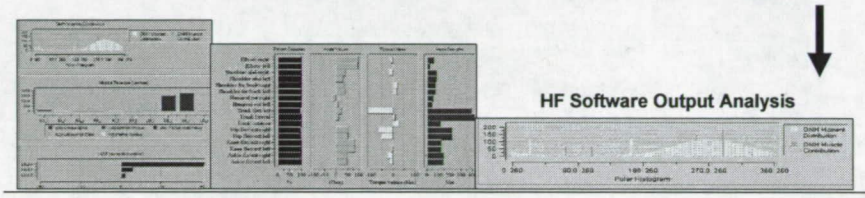
How it's Done: Flow of Activities



Real-time Task | Simulated Task | Motion Capture Simulation | HF Software Model



HF Software Output Analysis

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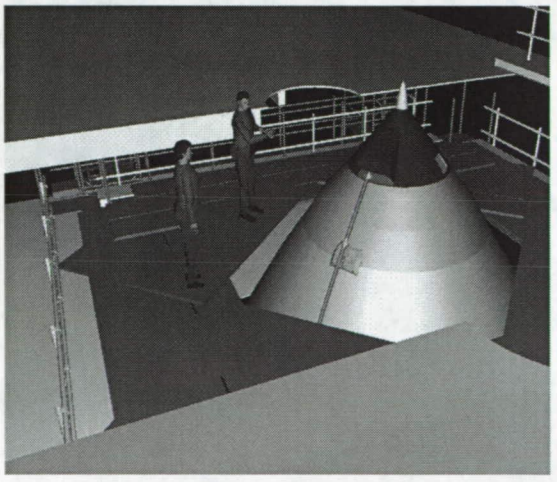
Project: ET Foam Application

Objectives:

- To ensure that techs can endure the foam spray operation safely
  - Factors involved: repetitive motion and fatigue
- To ensure that technicians fit safely in the environment
  - Factors involved: head clearance, tripping hazards, uneven platforms

Goal: To help flight certify the foam spray task on the ET for Mission STS-117



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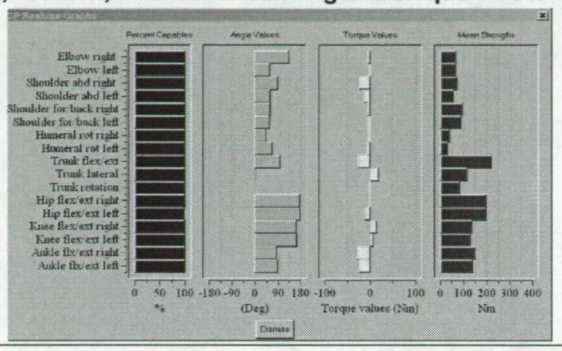
Project: ET Foam Application

Tools used:

Static Strength Prediction Tool

- **100% of the population is expected to have the static strength to perform the ET foam task for 60 minutes, based on the following:**
  - **Elbow, shoulder, hip, knee, and ankle; and the trunk angles for flexion, rotation, and lateral bending and torque on the limbs and trunk**



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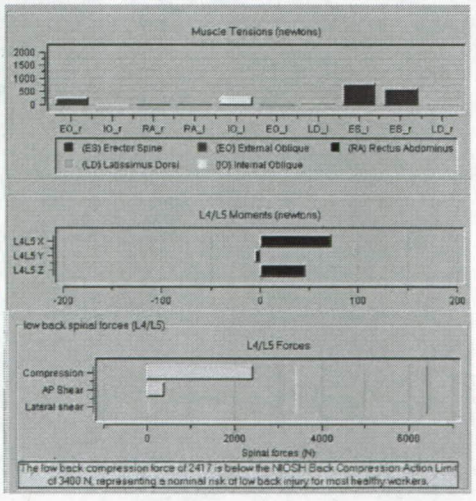
Project: ET Foam Application

Tools Used:

Lower Back Compression Analysis

- **Based on 60 minutes of foam spray time, compression and shear forces at the L4/L5 vertebral disc are within acceptable limits for this task, due to minimal bending and twisting**
- **Compression forces are within NIOSH/OSHA recommended and permissible lifting and force limits**
  - **Results are within the acceptable limits due to the optimal range of motion the task is performed (waist to shoulder height)**



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Project: ET Foam Application

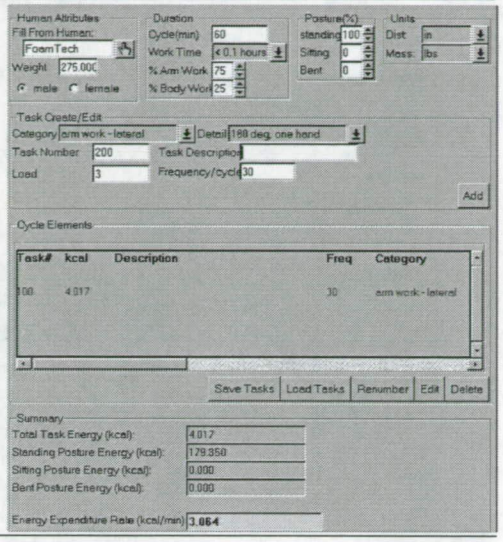
Tools Used:

Metabolic Energy Expenditure

- **Based on 60 minutes of foam spray time, energy expended for foam spray task is within the acceptable limits**

Work rest cycle

- **Based on a foam spray time of 60 minutes, a rest time of 4.74 minutes is recommended**
  - **Based on this information, this task is assumed to provide sufficient recovery time to avoid fatigue in the upper body**



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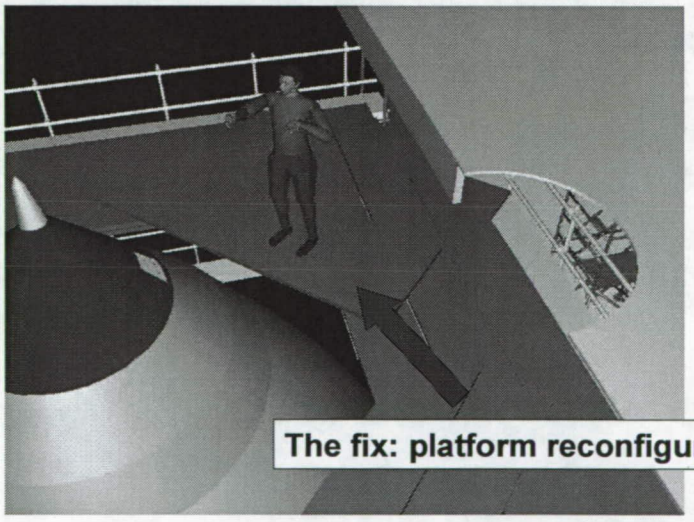
Project: ET Foam Application



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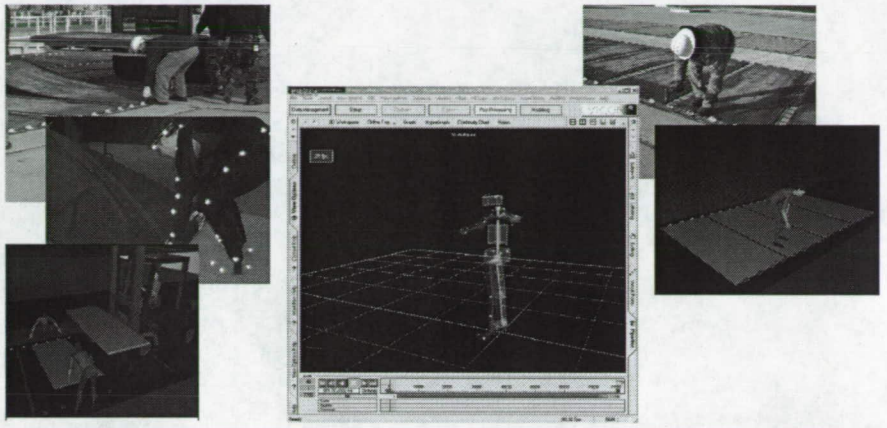
Project: Crawler Plywood

The problem: Repetitive lifting and bending to place 400 sheets of plywood on launch pad for crawler transporter, and hammering wedges into place to secure plywood on crawler path



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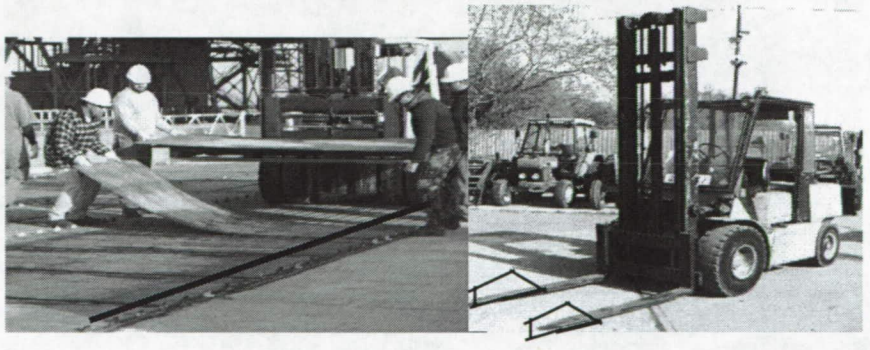
Project: Crawler Plywood

The fix: Cable system and forklift attachments to drop plywood into place



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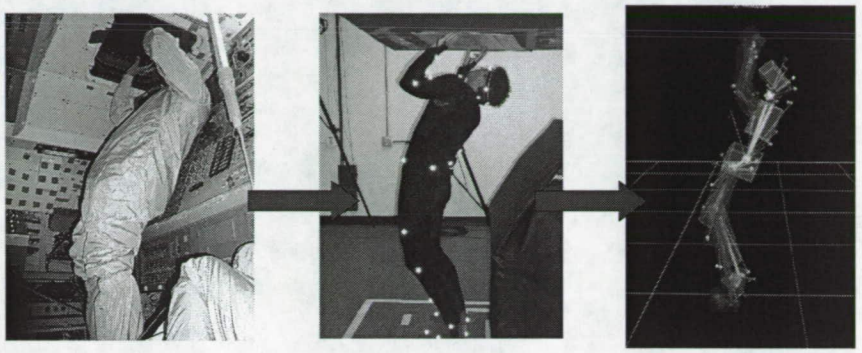
Project: Window Polycarbonate Cover Installation

The problem: Difficulty installing polycarbonate shields over orbiter windows. This is a static body position that requires the person to reach overhead for up to 20-30 minutes



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Project: Window Polycarbonate Cover Installation

The fix: Back and shield support

Back pad will extend 7 inches out from the panel and will run the length of the panel

Shield support will attach to bottom of panel and extend upward to hold the shield in place during build-up, eliminating the need for a human to manually hold the shield in place

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Project: Ingress/Egress through Orion Crew Hatch

- **A *proactive* approach to evaluate how employees will access and transport items through the crew hatch**

*So we are identifying potential **risks** before they become a problem!!!*

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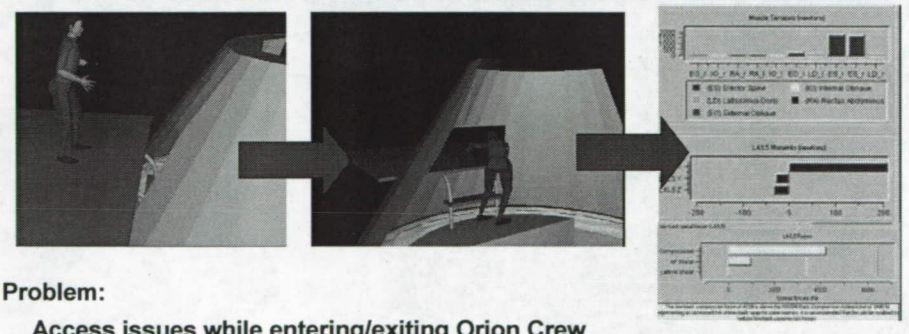
Project: Ingress/Egress through Orion Crew Hatch



Problem:

Access issues while entering/exiting Orion Crew Module

Plan:

To mitigate the excessive bending and twisting during ingress/egress

Simulated a worst case and best case scenario

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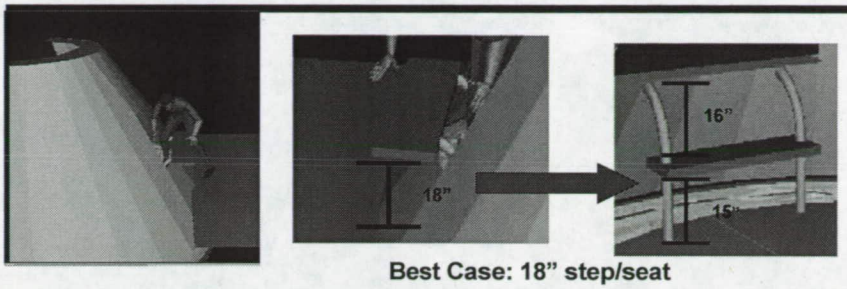
Project: Ingress/Egress through Orion Crew Hatch



Best Case: 18" step/seat

Worst Case:

- **Identified increased lower back compression forces while entering through the crew hatch when platform is flush with hatch entry**

Best Case:

- **Design a step/seat that is 18" above the platform for the technician to use for ingress/egress.**
  - **Reduces the low back compression forces, I.e., bending and twisting**

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Beyond Shuttle: Oh, the Possibilities…

- **What can YOU do to reduce risk to employees AND flight hardware in your environment?**
  - **Take the time to identify risks FIRST…down to the smallest tasks**
  - **Think PROACTIVE when designing new products OR processes—it's easier to change the design on paper than after it's been implemented!**
  - **Talk to the people who actually perform the work. Their input is invaluable.**
  - **RUN TESTS to identify optimal designs and configurations**
  - **WALK THROUGH the ENTIRE process, from start to finish, and remember to have a reaction plan for off-nominal situations**

- **During the design phase, interview the users and develop requirements to ensure a user friendly product….**

But remember it is the DESIGNER'S responsibility to identify the risk, minimize it, and provide an intuitive, error-free product!

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Questions

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